REMARKS

I. Introduction

By the present Amendment, claims 1 and 21 have been amended. Claim 22 is newly presented for consideration. Accordingly, claims 1 and 3-22 remain pending in the application. Claims 1 and 21 are independent.

II. Office Action Summary

In the Office Action of June 16, 2011, claims 1 and 9-21 were provisionally rejected on the ground of non-statutory obviousness type double patenting as being unpatentable over claims 1-8, 10-13, 15, and 16 of co-pending application No. 11/577,334; claims 1 and 8 of co-pending application No. 11/913,959; and claims 1-10, 12-15, and 17-19 of co-pending application No. 11/571,782. Claims 1 and 3-21 were rejected under 35 USC §103(a) as being unpatentable over U.S. Patent No. 6,381,197 issued to Savord et al. ("Savord") in view of U.S. Patent No. 6,183,419 issued to Wildes, and further in view of U.S Patent Application No. 2002/0198455 to Ossmann et al. ("Ossmann"). These rejections are respectfully traversed.

III. Double Patenting Rejections

Claims 1 and 9-21 were provisionally rejected on the ground of non-statutory obviousness type double patenting as being unpatentable over each of: claims 1-8, 10-13, 15 and 16 of co-pending application No. 11/577,33; claims 1 and 8 of co-pending application No. 11/913,959; and 1-10, 12-15, and 17-19 of co-pending application No. 11/571,782. Regarding these rejections, the Office Action indicates that although the pending claims are not identical to those of the cited applications, they are not patentably distinct from each other.

As these rejections are only provisional, Applicants elect to wait until the claims of either the instant application or the cited applications have been allowed, or indicated as allowable, in order to take steps most appropriate to address this rejection.

IV. Rejections under 35 USC §103

Claims 1 and 3-21 were rejected under 35 USC §103(a) as being unpatentable over Savord in view of Wildes, and further in view of Ossmann. Regarding this rejection, the Office Action indicates that Savord discloses a plurality of transducers for transmission and reception of ultrasonic waves where the semiconductor silicon oscillation elements (MUT elements) have an inherent characteristic of changing the electromechanical coupling coefficient in accordance with the strength of a direct-current bias. The Office Action indicates that Savord discloses a plurality of oscillation elements of equal number being divided into a plurality groups with equal intervals, a distance between each MUT element being variable for purposes such as aperture control, and the gain of each MUT element being variable to produce a different bias for each group in order to control apodization and elevation/image depth control. Savord is further indicated as disclosing a terminal with a distribution means connected to system electronics for control and bias purposes, as well as a switching means for selectively applying a bias when ultrasonic waves are transmitted and received.

The Office Action admits that Savord fails to specifically disclose adjusting the depth based on energizing different numbers of sections of oscillating elements in different groups. Wildes is relied upon for disclosing that varying the number of elements can directly impact the quality and focal depth of imaging. Wildes is further

relied upon for disclosing that varying groups of sections and elements can be arranged to optimize the clarity and focal depth of imaging, and that varying configurations of sections and groups can lead to better sharpness, focus, and resolution at varying depths. The Office Action concludes that it would been obvious to combine the teachings of Savord with the variable groupings of Wildes in order to create an efficient device with minimal electronic elements that would improve focus.

The Office Action goes on to admit that Wildes fails to specifically enumerate that the number of elements increases along the short axis in the direction of the center of the ultrasonic aperture. Ossmann is relied upon for disclosing a similar ultrasound transducer control wherein the apodization profile of an ultrasonic transducer array is controlled by altering the transducer elements. Ossman is further relied upon as disclosing a variety of patterns and control schemes for generating the patterns such that the pattern energy increases toward the center of the ultrasound aperture along a minor axis direction in order to reduce side lobes and increase precision. The Office Action concludes it would have been obvious to further combine the teachings of Savord and Wildes with those of Ossmann in order to arrive at the claimed invention.

By the present Amendment, Applicants have amended the claims to better define the invention by incorporating limitations that better clarify the features of the invention that are not believed to be shown or suggested by the art of record. As amended, independent claim 1 defines an ultrasonic probe that includes a plurality of transducers in an array for converting drive signals into ultrasonic waves to transmit the waves to an object to be inspected and converting the waves into electrical signals to receive ultrasonic waves generated from the object. In particular, independent claim 1 now recites the features:

the plurality of oscillation elements are divided into a plurality of groups including sections of the oscillation elements,

a number of the oscillation elements pertaining to each of the sections increases group-by-group as the position gets closer to the center of the ultrasonic aperture along a minor axis direction,

wherein the direct-current bias is applied group-by-group to the electrode of each of the oscillation elements in the minor axis direction, and

the transducers of the oscillation elements are separately located in a major axis direction with intervals.

According to some of the features of independent claim 1, the plurality of oscillation elements are divided into a plurality of groups including sections of the oscillation elements. Furthermore, a number of the oscillation elements pertaining to each of the sections increases group-by-group as the position gets closer to the center of the ultrasonic aperture in a minor axis direction. The direct-current bias is applied group-by-group to the electrode of each of the oscillation elements in the minor axis direction. Additionally, the transducers of the oscillation elements are separately located in a major axis direction with intervals.

As discussed in the Specification, the oscillation elements (34-1 – 34-30) may be arranged in the major-axis direction X of each transducer along with the dynamic focusing technique (or in place of the dynamic focusing technique), while the beam width in the major-axis direction X and the focal depth of the ultrasound beams may be controlled by applying direct-current biases having different strengths to each oscillation element. See paragraph [0062] of the published application. Furthermore, the oscillation elements can be divided into a plurality of groups in the major-axis direction, and direct-current biases having different values for each group may be applied to each of the oscillation elements. Although the transducers have the same number of oscillation elements within the same group, the number of

transducers can be increased as the position gets closer to the center of the ultrasonic aperture. See paragraph [0061].

As explicitly recited in independent claim 1, the transducers of the oscillation elements are separately located in the major axis direction, meaning that they are separated from each other. Thus, the structures and operations within the major axis direction and the minor axis direction from each other. Since the oscillation elements are finer than the piezoelectric elements, separating them is equivalent to fractionizaton of the transducer. This results in improved resolution of a two-dimensional ultrasound image. For example, the beam width in the major-axis direction and the focal depth of the transducers can be adjusted by performing dynamic focus on the reflection echo signal output from each transducer using the beam forming addition means. As least one benefit achieved by the invention of independent claim 1 is an ability to reduce the effect of the ultrasonic aperture, thereby resulting in an increase of the S/N of an ultrasound image. Furthermore, it becomes possible to control the sound-pressure distribution of the ultrasound beams in the major-axis direction for each section.

The Office Action alleges that the combination of references discloses all of the features recited in the claimed invention. Applicants respectfully disagree with this assertion, particularly in view of the clarifications that have been added to the instant claims. Savord discloses a micro-machined ultrasonic transducer which has aperture, elevation, and apodization controlled by an apparatus located on the same substrate as the transducer. A bias voltage control can alternatively be applied to the transducer elements. The control apparatus can be in the form of field effect transistors, micro-machined relays, or doped regions on the substrate. Savord appears to only disclose a plurality of oscillation elements being divided into a

plurality of groups having an equal number of oscillation elements, and varying the voltage to the MUT cells. There is no disclosure or suggestion for providing different structures and operations between the major axis direction and the minor axis direction. Furthermore, there is no disclosure or suggestion for physically separating the oscillation elements.

Wildes discloses a multiplexer for connecting a beamformer to a multi-row transducer array, wherein the number of electrically independent elements in the transducer is greater than the number of channels in the beamformer, thereby enabling dynamic selection and beamforming control of multi-row apertures. The active aperture can be scanned along at least one axis of the array while its shape is varied electronically. Each beamformer channel can also be connected to a single transducer element for near-field imaging and to a pair of adjacent transducer elements for far-field imaging. Wildes further indicates that the number of elements decreases toward the center of the aperture. Therefore, the total number of dark gray (or inner aperture) is smaller than medium gray and light gray (surrounding aperture). See column 8, lines 8 and 9, Table 1-2, and Figs. 7 and 8. Wildes appears to provide no disclosure or suggestion for different structures and operations between the major and minor axis directions, as well as physically separating the oscillation elements.

Ossmann discloses a variable multi-dimensional apodization control for an ultrasonic transducer array. The system allows the apodization profile of an ultrasonic transducer array to be controlled, and is applicable to both piezoelectric based transducers and MUT based transducers. Ossmann merely indicates that the ultrasonic transducer array can have elements arranged in more than one direction, and that the selective apodization of all dimensions of an aperture of the ultrasonic

transducer array can be varied between a transmit cycle and a received cycle. There is no disclosure or suggestion for providing different structures and operations between the major and minor axis directions, or for physically separating the oscillation elements. Since all of the cited references fail to provide any disclosure or suggestion for the same features recited in the claimed invention, the combination of these references necessarily fails to provide any disclosure or suggestion for features now recited in independent claim 1, such as:

> a number of the oscillation elements pertaining to each of the sections increases group-by-group as the position gets closer to the center of the ultrasonic aperture along a minor axis direction,
>
> wherein the direct-current bias is applied group-by-group to the electrode of each of the oscillation elements in the minor axis direction, and
>
> the transducers of the oscillation elements are separately located in a major axis direction with intervals.

It is therefore respectfully submitted that independent claim 1 is allowable over the art of record.

Claims 3-20 and 22 depend from independent claim 1, and are therefore believed allowable for at least the reasons set forth above with respect to independent claim 1. In addition, these claims each introduce novel elements that independently render them patentable over the art of record.

As amended, independent claim 21 defines a method for ultrasonic imaging that comprises:

> applying a direct-current bias to a plurality of oscillation elements possessed by each transducer arrayed in an ultrasonic probe and changing an electromechanical coupling coefficient of each of the oscillation elements to a setting value;
>
> supplying a drive signal to each of the oscillation elements by superposing the drive signal on the direct-current bias, transmitting an ultrasonic wave to an object to be inspected from each of the oscillation elements; and

receiving an ultrasonic wave generated by the object by each of the oscillation elements to convert the wave into an electrical signal and reconstructing an ultrasound image based on the converted electrical signal,

wherein:

the plurality of oscillation elements are divided into a plurality of groups including sections of the oscillation elements,

a number of the oscillation elements pertaining to each of the sections increase group-by-group as the position gets closer to the center of the ultrasonic aperture along a minor axis direction,

the direct-current bias is applied group-by-group to the electrode of each of the oscillation elements in the minor axis direction, and

the transducers of the oscillation elements are separately located in a major axis direction with intervals.

Independent claim 21 recites various features that correspond to those recited in independent claim 1. In particular, independent claim 21 now specifies that the direct-current bias is applied group-by-group to the electrode of each of the oscillation elements in the minor axis direction. Additionally, the transducers of the oscillation elements are separately located in a major axis direction with intervals. As previously discussed, the combination of cited references fails to provide any disclosure or suggestion for such features.

It is therefore respectfully submitted that independent claim 21 is allowable over the art of record.

V. Conclusion

For the reasons stated above, it is respectfully submitted that all of the pending claims are now in condition for allowance. Therefore, the issuance of a Notice of Allowance is believed in order, and courteously solicited.

If the Examiner believes that there are any matters which can be resolved by way of either a personal or telephone interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

AUTHORIZATION

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 389.46065X00).

Respectfully submitted,
ANTONELLI, TERRY, STOUT & KRAUS, LLP.

/Leonid D. Thenor/
Leonid D. Thenor
Registration No. 39,397

LDT/vvr
1300 N. Seventeenth Street
Suite 1800
Arlington, Virginia 22209
Tel: 703-312-6600
Fax: 703-312-6666

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